

# Magnet Issues for Main Injector at a Higher Repetition Rate

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# High Repetition Rate

- Magnet design is for 1.5 second repetition rate in p-bar stacking, or 1.9 second repetition rate for slow spill.
- High repetition rate here means 1 second.
- This implies doubling the ramp rate.
- Average resistive power level is reduced.

# Draft Table of Contents

- Voltage to ground
- Field quality as a function of rep rate
- Sextupole (eddy current) strength
- Heating
- Corona test

# Magnet Types

- Ring dipoles
- Ring quadrupoles
- Ring sextupoles
- Ring trim dipoles
- Ring higher order trims
- Lambertson magnets
- ... Not to mention beam lines

# Voltage to Ground Production Hipot Tests

Magnet Type	Test voltage	Power supply (2x volts to ground)
Dipoles	5000 V	1000 V $\rightarrow$ 2000 V
Quadrupoles	1500 V	850 V $\rightarrow$ 850 V
Sextupoles	1500 V	750 V $\rightarrow$ ? V
Trim dipoles	500 V	$\rightarrow$ ?
Higher order correctors	500 V	80 V $\rightarrow$ ?
Lambertson magnets	2000 V	200 V $\rightarrow$ ?

# Voltage to Ground

- All magnets are designed to handle the required voltage to ground.
- See also Corona test.

# Field quality as a function of repetition rate

- Only dipoles are an issue:
- No reason to expect any variation in field shape due to poles during acceleration.
- Small strength, sextupole variation possible at injection (see TDH section 3.1 p 15 and references), but easily accommodated.

# Beam tube eddy current sextupole

- Doubled ramp rate will double the sextupole from eddy currents in the beam tube.
- Opposite sign from the sextupole due to saturation of the steel.
- Dominant effect at low fields, but chromaticity sextupoles sized for saturation field at 150 GeV/c, so plenty of strength.  
(MI-0100, [http://www-fmiinternal.fnal.gov/MI\\_Notes\\_Pages/MI-0100.pdf](http://www-fmiinternal.fnal.gov/MI_Notes_Pages/MI-0100.pdf))
- Need to check sextupole rate for power supply limit.



# Heating

- Fast repetition rate running is less demanding in resistive losses than slow extraction, for which the system was designed.
- Magnets all run DC at full excitation during testing with a smaller differential pressure than is available in the tunnel.

# Corona Testing

- September 2000 Chez Jach performed a corona test on one spare FMI dipole.
- Extinction voltage corresponded to about 535 V, compared to typical maximum voltage to ground of 500 V.
- No work was done on the many sharp corners at the ends, so there is potential for improvement.
- No measurements on quadrupoles, but voltages will not change.

# Conclusions

- Magnets will be good for high repetition rate running.
- Partial discharge testing of dipoles should look for major contributing factors.
- Sextupole ramp needs exploration with respect to power supply slew rate.